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Braaksma, Petra; Stuive, Ilse; Boomsma, Hinke; van der Sluis, Corry K; Schoemaker, Marina M; Dekker, Rienk

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# BMJ Open We12BFit!-Improving lifestyle physical activity in children aged 7-12 years with developmental coordination disorder: protocol of a multicentre single-arm mixed-method study

Petra Braaksma,<sup>1</sup> Ilse Stuive,<sup>2</sup> Hinke Boomsma,<sup>2</sup> Corry K van der Sluis,<sup>1</sup> Marina M Schoemaker,<sup>3</sup> Rienk Dekker<sup>1</sup>

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<sup>1</sup>Department of Rehabilitation Medicine, University of Groningen, University Medical Center Groningen, Groningen, The Netherlands

<sup>2</sup>Center for Rehabilitation, University of Groningen, University Medical Center Groningen, Groningen, The Netherlands

<sup>3</sup>Center for Human Movement Sciences, University of Groningen, University Medical Center Groningen, Groningen, The Netherlands

## Correspondence to

Dr Petra Braaksma;  
[p.braaksma@umcg.nl](mailto:p.braaksma@umcg.nl)

## ABSTRACT

**Introduction** Children with developmental coordination disorder (DCD) are less physically active than their typically developing peers. No substantiated interventions are available to address this issue. Therefore, this study aims to describe the design and rationale of (1) a family-focused intervention to increase motivation for physical activity (PA) and, indirectly, lifestyle PA in children aged 7–12 years with DCD and (2) the methods to examine its preliminary effectiveness and feasibility.

**Methods and analysis** This intervention is the second part of a more comprehensive, multidisciplinary treatment called We12BFit! The intervention was developed using the steps of treatment theory which includes the concept of targets, mechanism of action and essential ingredients. The content of the intervention is based on the transtheoretical model of change (TTM). In the intervention, the motivation for PA will be targeted through application of behaviour change strategies that fit the stages of the TTM. The modes of delivery include: pedometer, poster, parent meeting, booklet and coaching. At least 19 children with DCD, aged 7–12 years, will be included from two schools for special education and two rehabilitation centres. The intervention will be evaluated using a single-arm mixed-method design. Effectiveness will be assessed at three instances by using ActiGraph accelerometers accompanied by an activity log. Feasibility will be assessed using interviews with the participants and coaches. This evaluation may add to our understanding of motivation for PA in children with DCD and may eventually improve the rehabilitation programme of children with DCD.

**Ethics and dissemination** The study has been approved by the Medical Ethics Committee of the University Medical Center of Groningen (METc 2015.216). We will disseminate the final results to the public through journal publications and presentations for practice providers and scientists. A final study report will also be provided to funding organisations.

**Protocol version** 4, 12 April 2018.

**Trial registration number** NTR6334; Pre-results.

## Strengths and limitations of this study

- A multicentre single-arm study using a mixed-method design to examine the preliminary effectiveness and feasibility of a lifestyle physical activity intervention for children aged 7–12 years with developmental coordination disorder.
- Focus on systematic and evidence-based development and reporting of the intervention using treatment theory.
- Attention to different stages of motivation and a strong focus on engaging parents.
- No control group was included.
- The study timeframe is limited to 6 months which is not suited to ascertain long-term effects on behaviour.

## INTRODUCTION

Children with developmental coordination disorder (DCD) experience difficulties in the execution and acquisition of coordinated motor skills.<sup>1</sup> Over the years, it has become evident that children with DCD are less physically active than their typically developing peers.<sup>2 3</sup> Especially, their participation in free and organised activities is compromised, and they also tend to engage in less intensive activities.<sup>2 3</sup> In the school playground, children with DCD spend more time alone and are onlookers more often than their peers.<sup>4</sup>

The hypoactivity of children with DCD has been linked to low self-efficacy towards physical activity (PA)<sup>5</sup> and inefficient movement patterns that may lead to earlier fatigue.<sup>6 7</sup> These factors may tie into a negative cycle where poor motor coordination leads to lower participation in PA and deconditioning.<sup>6 8</sup> This cycle reinforces itself, thereby making it increasingly difficult to make a change. Low levels of physical fitness

(PF) and PA in childhood tend to track into adulthood and are related to an increased risk of cardiovascular diseases.<sup>9 10</sup> The seriousness of the aggravating short-term and long-term consequences for health and participation emphasises the need to improve the PA of children with DCD in addition to treating their motor coordination.

To our knowledge, only two interventions have focused on improving PA in children with DCD. In a single-arm study, Howie *et al*<sup>11</sup> provided 21 children with DCD with commercially available active video games over 16 weeks. They hypothesised that PA might improve directly by playing the games or indirectly by improving motor coordination or self-efficacy. After the intervention, they found no significant improvements in self-esteem, enjoyment of PA and objective measures of PA.<sup>11 12</sup> However, self-reports indicated that the children participated more in walking and ball games. Unfortunately, self-reports also indicated that the children spent less time outdoors on weekends which was presumably due to spending more time gaming indoors.<sup>11</sup> In another study, Hillier *et al*<sup>13</sup> offered children with DCD six 30 min individual aquatic training sessions over a period of 6–8 weeks. Parent reports of the children's participation in activities indicated that the waitlist control group improved even slightly more than the intervention group. These negative results may indicate that interventions that aim to increase PA through self-efficacy, motor coordination or PF need improvement and that an approach that directly targets motivation for PA incorporating evidence-based behaviour change strategies is required.

Importantly, to date, there is no effective and systematically developed intervention that specifically focuses on improving motivation for PA behaviour in children with DCD. The present study describes the development of an intervention to improve motivation for PA and indirectly lifestyle PA in children with DCD. Changing lifestyle PA is not merely a matter of overcoming obstacles but also draws heavily on broader motivational processes and therefore poses many challenges to both the children and their parents.<sup>14</sup> The transtheoretical model of change (TTM) of Prochaska elucidates the complexity of such a behavioural change process.<sup>14</sup> The TTM is a biopsychosocial model that integrates constructs from different behaviour change theories. It defines several stages of change over time, ranging from precontemplation to maintenance of the intended behaviour. For each stage, different processes are identified that may facilitate progress to the next stage. Importantly, the process of behaviour change is not necessarily progressive but may include periods where people are stuck in a certain stage, or even regress to an earlier stage of change. Using the TTM in behaviour change interventions allows professionals to flexibly adapt to the stage of change of each individual participant. As parents are responsible for their children and have both practical and behavioural resources to influence their children, the intervention should not just focus on children but also on their parents.<sup>15–17</sup>

For such a complex and tailored intervention, a sound theoretical foundation is needed. The steps for developing a treatment theory as defined by Whyte *et al*<sup>18 19</sup> will therefore be used to systematically develop the intervention. A treatment theory necessitates a clear definition of the treatment targets, mechanism of action and essential ingredients. A target is the 'Aspect of the recipient's functioning, or personal factor, that is predicted to be directly changed by the treatment's mechanism of action.' (Whyte *et al*, pS25)<sup>19</sup> This mechanism of action describes the 'Process by which the treatment's essential ingredients induce change in the target of treatment.' (Whyte *et al*, pS32.e1)<sup>19</sup> Essential ingredients are 'Active ingredients, selected or delivered by the clinician (...) and are hypothesised or known to be necessary for the treatment's effect on the target.' (Whyte *et al*, pS32.e1)<sup>19</sup> Essential ingredients should be distinguished from other active ingredients that moderate the treatment effect.

In the present study, we describe the design and rationale of a single-arm mixed-method study to evaluate the preliminary effectiveness and feasibility of an intervention to improve motivation for PA and eventually lifestyle PA in children aged 7–12 years with DCD: We12BFit!-Lifestyle PA. We hypothesise that the target motivation, and indirectly lifestyle PA, will improve and that the intervention will be feasible. We12BFit!-Lifestyle PA is the second part of a more comprehensive, multidisciplinary treatment called We12BFit!. The first part, We12BFit!-PF, is aimed at improving the children's PF by using a 10-week group training, including high-intensity interval training, strength and plyometric exercises, before improving their PA.<sup>20</sup>

## METHODS AND ANALYSIS

### Study design

This study is designed as a multicentre single-arm study. Preliminary effectiveness and feasibility will be evaluated using mixed-methods. As this study concerns a newly developed intervention, we will examine the preliminary effectiveness and feasibility to optimise the intervention. Therefore, no control group will be included at this stage of development.

### Participants

This study will be conducted at two Dutch rehabilitation centres and two schools for special education. All rehabilitation centres in the Netherlands and physical therapists in the province of Groningen will receive an invitation to participate in the study. Locations will be selected based on willingness to participate, availability of coaches and trainers, and having appropriate facilities. Children will be included if they are:

1. Previously diagnosed with DCD, by a physician according to Diagnostic and Statistical Manual of Mental Disorders (DSM-V) criteria<sup>1</sup> or when DSM-V criteria A, B and C are met and criterion D is checked in school records (probable DCD).

2. Age 7–12 years.
3. Asking for help regarding enhancing PA.
4. Motivated to participate in the intervention.
5. If their parents/caretakers are willing to invest their time and effort in the intervention.

Children will be excluded if they:

1. Have insufficient understanding of Dutch/English language to participate successfully in the intervention.
2. Have a medical status that contraindicates exercise or maximal exercise testing.
3. Are unable to function in a group: assessed by physician or therapist, for example, the child is unable to participate in PE classes or sports activities or disturbs the activities of other children.
4. Are unable to follow instructions: assessed by physician or therapist, for example, the child is easily distracted, refuses to execute instructions or does not understand basic instructions.

Exclusion criteria 2, 3 and 4 are related to We12BFit!-PF, and comorbidities such as Autism Spectrum Disorders and Attention Deficit Hyperactivity Disorder are not considered for exclusion.

Between 2015 and 2018, a convenience sample of at least 19 children will be recruited through their (school) physical therapist, occupational therapist or rehabilitation physician. Participants will engage in both parts of We12BFit! All children with DCD and their parents in the selected rehabilitation centres and schools will be informed about the opportunity to participate in the intervention by an informational letter. Prior to their participation, the parents and their child will be invited for an intake. During the intake, the inclusion and exclusion criteria will be checked, and information on the intervention will be provided.

## Intervention

The intervention was developed using the steps of treatment theory as defined by Whyte *et al.*<sup>19</sup> and the content of the intervention is based on the TTM (see figure 1).

### Step 1: target

Following the terminology of the TTM, the target of We12BFit!-Lifestyle PA is motivation for PA of children and their parents, indirectly aiming for an increase in children's lifestyle PA. Lifestyle PA is defined as 'The daily accumulation of at least 30 min of self-selected activities,

which includes all leisure, occupational, or household activities that are at least moderate to vigorous in their intensity and could be planned or unplanned activities that are part of everyday life.' (Dunn *et al.*, p.399)<sup>21</sup> However, as this study concerns children, lifestyle PA should be 60 min daily.

### Step 2: mechanism of action

The mechanism of action and the corresponding essential ingredients are based on the TTM. The TTM defines five stages of change and stage-specific processes that occur when people progress from one stage to the next stage. For example, for moving from the precontemplation stage to the contemplation stage, it is necessary to raise consciousness, work on negative and positive emotions associated with the behavioural change and re-evaluate the environment. The nine stage-specific processes described in table 1 are considered as the mechanisms of action.

### Step 3: essential ingredients

Multiple appropriate behaviour change strategies as defined by Michie *et al.*<sup>22</sup> were selected for each stage of change and its corresponding processes (mechanism of action). These behaviour change strategies form the essential ingredients of the intervention. Table 2 provides an overview of the mechanism of action, corresponding essential ingredients and their operationalisation. For example, for the mechanism of consciousness raising, the corresponding essential ingredient is prompting self-monitoring of behaviour which is operationalised by the provision of pedometers to children and their parents.

As the word 'transtheoretical' indicates, the TTM integrates strategies from different behaviour change theories. This includes strategies from social cognitive theory, problem-solving therapy, cognitive behavioural therapy and motivational interviewing. For example, social cognitive theory is reflected in making parents role models<sup>23</sup>; problem-solving therapy is reflected in the identification of barriers, goal setting and graded tasks<sup>17</sup>; cognitive behavioural therapy is reflected in evaluating cognitive barriers; and motivational interviewing is reflected in identifying benefits of the intended behaviour.<sup>24</sup> Moreover, other strategies recommended specifically for lifestyle interventions in children such as restructuring the home environment by adding activity cues, prompting self-monitoring and providing contingent rewards were included.<sup>17</sup> Supporting strategies such as provision of information and action planning were added.

The behaviour change strategies will be directed primarily at the parents, as high parental involvement is considered beneficial for lifestyle interventions in children.<sup>17</sup> As the participants register for the intervention voluntarily, we expect them to be at least in the preparation stage of change. However, the intervention will deal with both children and their parents, and they may differ in their stage of change. Further, the participants

Development	Content
Treatment theory	Transtheoretical model of change
Step 1: Target	Motivation for PA
Step 2: Mechanism of action	Stage-specific processes of TTM
Step 3: Essential ingredients	Behaviour change strategies

**Figure 1** Overview of treatment theory development steps and content. PA, physical activity; TTM, transtheoretical model of change.



**Table 1** TTM definitions of stages of change and corresponding processes (cited from Prochaska *et al*)<sup>14</sup>

Stage of change	Corresponding stage-specific processes
A. Precontemplation (PC): 'No intention to take action within the next 6 months'	1. Consciousness raising: 'Increasing awareness about the causes, consequences, and cures for a problem behaviour: for example, nutrition, education'.
	2. Dramatic relief: 'Increasing negative or positive emotions (e.g., fear or inspiration) to motivate taking appropriate action: for example, personal testimony'.
	3. Environmental re-evaluation: 'Cognitive and affective assessment of how the presence or absence of a behaviour affects one's social environment, such as the impact of one's smoking on others: for example, empathy training'.
B. Contemplation (C): 'Intends to take action within the next 6 months'	4. Self-reevaluation: 'Cognitive and affective assessment of how the presence or absence of a behaviour affects one's social environment, such as the impact of one's smoking on others: for example, empathy training'
C. Preparation (PP): 'Intends to take action within the next 30 days and has taken some behavioural steps in this direction'	5. Social liberation: 'Increase in healthy social opportunities or alternatives: for example, easy access to walking paths'.
D. Action (A): 'Changed overtbehaviour for less than 6 months'	6. Helping relationships: 'Caring, trust, openness, and acceptance as well as support from others for healthy behaviour change: for example, a positive social network'.
	7. Counterconditioning: 'Learning healthier behaviours that can substitute for problem behaviours: for example, relaxation replacing alcohol'.
	8. Stimulus control: 'Removing cues for unhealthy habits and adding prompts for healthier alternatives: for example, removing all ashtrays from house and car'.
E. Maintenance (M): 'Changed overt behaviour for more than 6 months'	9. Reinforcement management: 'Rewarding oneself or being rewarded by others for making progress: for example, incentives'.
The processes listed for each stage apply to the transition from that stage to the next.	

may have moved to a different stage of change between registration and the start of the intervention. Therefore, although less extensive, we will also incorporate

behavioural change strategies related to precontemplation and contemplation.

The operationalised behavioural change strategies shown in table 2 will be delivered in five different modes:

1. Pedometer (Fitbit Zip): The pedometer is intended for consciousness raising, providing insight in personal PA and providing input for goal setting. It may also offer support when not just the child but also other members of the family wear the pedometer. Several pedometers will be provided to each family during the intervention. The use of pedometers has been shown to increase PA.<sup>25</sup>
2. Poster: The poster will be used during the training sessions that are offered in We12BFit!-PF. The poster will be used to support the use of the pedometer, to engage the children in moving towards being more active, and to inspire the children. During the training, the trainers will ask the children to share their latest and most fun endeavours to make steps. The children can write down or draw their input on a joint poster.
3. Parent meeting: The parent meeting is designed to inform parents of children with DCD about We12B-Fit-Lifestyle PA, and to provide basic knowledge about PA and how to motivate children with DCD to be active. The meeting also is an opportunity for the parents to talk to other parents who may experience similar problems with their children.
4. Booklet: During the parent meeting, all the parents will receive a printed booklet with information on increasing lifestyle PA and making this a habit. The booklet is a translated and adapted version of the information provided to the participants in a study by Newton *et al*.<sup>26</sup> In this study, a parent-targeted mobile phone intervention was conducted to increase PA in sedentary children. The number of articles read by the parents was significantly correlated to the increase in steps/ day of the children.
5. Coaching: The coaching will be conducted by a trained coach, working in the field of rehabilitation, who is familiar with the target group. During eight 30 min coaching sessions, the children and their parents will set PA goals and evaluate these over time. The coaching will be tailored to each participant's stage of change and individual needs, including needs related to DCD. The coaching will focus on the parents. The children will be engaged in the beginning of the coaching session. If necessary, the information from the parent meeting and the booklet will be reiterated during the coaching. The first coaching session is face to face, and the remaining sessions are conducted by telephone or video chat.

The information that will be provided in the parent meeting, booklet and coaching sessions is organised to maximise retention by using chunking, scaffolding and iteration of information in different modes of presentation.<sup>27</sup>

We12BFit!-Lifestyle PA will start in week 6 of We12BFit!-PF and continue until 12 weeks after the last

**Table 2** Tripartite structure of the intervention definition: target, mechanism of action (process) and ingredients (behavioural change strategies)

**Target: motivation for PA**

Mechanism of action		Essential ingredients		
Process (stage of change)*		Behavioural change strategy used for child and/or parent†		Operationalisation of behavioural change strategy
1.	Consciousness raising (PC, C)	1	Provide information on consequences of behaviour in general	Information for parents on effects of: PA/inactivity/sedentary behaviour, playing outdoors (meeting, booklet).
		ND	Information on guidelines	Information on norms for being active and screen time (meeting, booklet).
		16	Prompt self-monitoring of behaviour	Use of Fitbit Zip pedometers for children and their parents.
		10	Prompt review of behavioural goals	► Inquiry about Fitbit steps with parents and children (coaching). ► Evaluation of goals with children and parents (coaching).
		37	Motivational interviewing	Among others: asking children and parents about the advantages of being physically active (coaching).
2.	Dramatic relief (PC, C)	1	Provide information on consequences of behaviour in general	Information for parents on effects of: PA/inactivity/sedentary behaviour, playing outdoors (meeting, booklet).
		37	Motivational interviewing	Among others: asking children and parents about the advantages of being physically active (coaching).
3.	Environmental re-evaluation (PC, C)	30	Prompt identification as role model/ position advocate	Information on the importance, mechanism and examples of parents' function as a role model for PA to their child (booklet).
4.	Self-reevaluation (C, PP)	ND	Experience success	During the training sessions (We12BFit!-PF), children are able to experience what they are capable of and are given opportunities for experiencing success in PA. When parents are present during the training sessions, they get a chance to see the improvements their child makes and what their child is capable of.
5.	Self-liberation (PP, A)	8	Barrier identification/problem solving	Identifying and addressing cognitive barriers of children and parents with regard to being physically active (coaching).
		5	Goal setting (behaviour)	► Information on goal setting for parents (booklet). ► Goal setting with children and parents (coaching).
		9	Set graded tasks	► Information for parents to set graded tasks to allow for success (booklet). ► Goal setting with children and parents (coaching).
		7	Action planning	Assignment for parents to plan activities for the week: day, duration, activity (booklet, coaching).
		38	Time management	Information on how to make time for PA (booklet).
6.	Social liberation	ND	Drawing attention to potential activities	► Information on potential activities to engage in (booklet). ► Exploration of potential activities to engage in (events, sports clubs, playgrounds) (coaching).
7.	Counterconditioning (A, M)	ND	Replacing problem behaviours with healthier behaviours	► Advice to reduce sedentary/less intensive activities by replacing them with PA, for example, active games instead of sedentary games, bike instead of car, stairs instead of elevator (booklet). ► Information on replacing cues for inactivity by cues for activity (booklet).
			(Parent>child)	► Advice on how to improve children's PA: also use small opportunities for activity, facilitate PA, use positive communication, adapt choice of activities/type of goals/type of motivation to the child, offer the child choices, set rules to limit screen time, see it as practice and keep practising (meeting, booklet).
		8	Barrier identification/problem solving	► Information on identifying and addressing behavioural, cognitive, emotional, environmental, social and/or physical barriers of children and parents with regard to being physically active (booklet). ► Identifying and addressing behavioural, cognitive, emotional, environmental, social and/or physical barriers of children and parents with regard to being physically active (coaching).
8.	Helping relationships (A, M)	29	Plan social support/social change	► Information on the importance and ways of receiving support as parents (booklet). ► Inquiry on receiving social support with parents (coaching).
		29	(Parent>child) Plan social support/ social change	► Information on the importance and ways of providing support as parents (booklet). ► Discussing provision of social support, with parents (coaching). ► Use of Fitbit Zip pedometers for children and their parents.
		30	(Parent>child) Prompt identification as role model	Information on the importance, mechanism and examples of parents' function as a role model for PA to their child (booklet).
9.	Reinforcement management (A, M)	13	(Parent>child) Provide rewards contingent on successful behaviour	Information on the importance of rewarding and how and when to reward children for being physically active (booklet).

Continued

**Table 2** Continued

Target: motivation for PA

Mechanism of action	Essential ingredients		
Process (stage of change)*	Behavioural change strategy used for child and/or parent†		Operationalisation of behavioural change strategy
10. Stimulus control (A, M)	23	Teach to use prompts/cues	<ul style="list-style-type: none"> <li>► Information on removing cues for inactivity (booklet).</li> <li>► Information on creating cues for activity (booklet).</li> </ul>

\*Process and stages of change as defined by Prochaska *et al*<sup>14</sup> (see table 1).†Behaviour change strategy as defined and numbered by Michie *et al*.<sup>22</sup>A, action; C, contemplation; M, maintenance; ND, not defined by Michie *et al*<sup>22</sup>; PA, physical activity; PC, precontemplation; PP, preparation.

training. The frequency of We12BFit!-Lifestyle PA will decrease towards the end of the intervention (see table 3 for the timeline and frequency).

### Patient and public involvement

The research question was brought up by paediatric physical therapists who noticed that children with DCD experience problems with PF and PA and looked for an evidence-based approach to improve this situation. In response to this, we examined the PF and PA of children with DCD.<sup>2 28 29</sup> Two parents were interviewed about the role of the parent in activating the child and how they motivate their child to be active. In addition, the intervention was developed in close collaboration

between paediatric psychologists, paediatric physical therapists and a paediatric rehabilitation physician with ample experience in treating children with DCD.

As part of the actual We12BFit! intervention, participants will set their personal goals during the intake and coaching sessions. The participants will be asked to contribute to a video to inform potential participants about the intervention. We12BFit!-Lifestyle PA will be evaluated in parent interviews afterwards. The suggestions provided in these interviews will be used to improve the intervention. Participants will be informed about their personal results after the intervention, and the overall research results will be presented to them in a newsletter.

**Table 3** Timeline of We12BFit!

Action	Week	0	1	2	3	4	5	6	7	8	9	10		
Intake		x												
Measurements (T0)		x												
1. We12BFit!-PF*														
Training			xx	xx	xx	xx	xx	xx	xx	xx	xx	xx		
2. We12BFit!-Lifestyle PA														
Pedometer								x	x	x	x	x		
Poster								x	x	x	x	x		
Parent meeting								x						
Booklet								x	x	x	x	x		
Coaching										x				
	Week	11	12	13	14	15	16	17	18	19	20	21	22	23
Intake														
Measurements (T1, T2)		x												x
1. We12BFit!-PF*														
Training														
2. We12BFit!-Lifestyle PA														
Pedometer		x	x	x	x	x	x	x	x	x	x	x	x	
Poster														
Parent meeting														
Booklet		x	x	x	x	x	x	x	x	x	x	x	x	
Coaching		x	x	x	x		x		x			x		

\*Described elsewhere.<sup>20</sup>

PA, physical activity; PF, physical fitness.

## Compliance

Compliance will be promoted by closely following the participants: during coaching sessions, coaches will actively motivate the participants, check for any problems that the participants may encounter and help the participants to solve these issues. Moreover, after each session, the coach will evaluate the session with the participants to improve adherence.

## Sample size calculation

As no representative data is available regarding PA measures for the target group, the required sample size for this study is based on the primary outcome measure for the evaluation of We12BFit!-PF,<sup>20</sup> the  $VO_{2peak}$  (ml/kg/min) as attained from the 20m Shuttle Run test. We aim for an improvement of at least 5% in the mean percentage of change in  $VO_{2peak}$  found across different studies for improving  $VO_{2peak}$  in children.<sup>30</sup> By using mean  $VO_{2peak}$  from preliminary research ( $x_1$ ),<sup>29</sup> mean  $VO_{2peak}$  after 5% improvement ( $x_2$ ), SD (s) and at least moderate Pearson correlation ( $r > 0.3$ ), we calculated the effect size  $d$ ,  $d = |x_1 - x_2| / (SD \times (1 - r)^{0.5})$ . Subsequently, the sample size was calculated based on a two-tailed test with a power of 80% and alpha of 0.05. This resulted in a required sample size of at least 19 children.

## Outcomes

Mixed-methods will be used to examine the preliminary effectiveness and feasibility of the intervention.

### Preliminary effectiveness: quantitative data collection

The preliminary effectiveness of PA will be assessed objectively using ActiGraph wGT3x-BT triaxial accelerometers at three instances (see table 3). The ActiGraph has been shown to be a valid tool for measuring PA in children.<sup>31</sup> The ActiGraph will be used for the evaluation of preliminary effectiveness, whereas the Fitbit Zip pedometer will be used as an ingredient of the intervention. The participants will be verbally instructed on how to wear the ActiGraph. They will also receive written information on this. To support adherence, the participants will be provided with a leaflet to remind them to wear the ActiGraph. The children will wear the ActiGraph around the waist during all waking hours, except when engaging in water activities, for a period of 7 days on three instances: before We12BFit!-PF, after We12BFit!-PF training and after We12BFit!-Lifestyle PA. The ActiGraph data will be recorded using 30 Hz sampling frequency.

### Preliminary effectiveness: qualitative data collection

In addition to wearing the ActiGraph, the participants will be asked to use a log to register wear time and qualitative aspects such as type of activities, with whom they engage in the activities and mode of transportation. The log will also include background questions on distance to school, mode of transportation to school, sports and family situation (see online supplementary appendix A). The participants will be verbally instructed on how to fill

the log, and the leaflet with the reminder to wear the ActiGraph also mentioned the use of log.

During parent interviews after the intervention, the parents will be asked about the effects of We12BFit!-Lifestyle PA (see online supplementary appendix B).

### Feasibility: qualitative data collection

Feasibility will be assessed by interviews with parents and coaches after the intervention. The questions will focus on the acceptability and practicality of the four targets and the five modes of delivery (see online supplementary appendices B and C). The questions of the interview guides for parents and coaches will be matched. All the interviews will be audiotaped and transcribed verbatim and anonymously afterwards. The respondents will receive a summary of the interview by email as a member check. The Consolidated criteria for reporting qualitative research checklist will be used to report the results of the interviews.<sup>32</sup> Drop-outs will be asked for reasons for withdrawing their participation.

### Data management

The data will be collected by a team of researchers and students. The students will download and deidentify the data, and the researchers will conduct the data analysis. The data will be stored securely in password-protected computer files and in locked cabinets at the University Medical Center Groningen. Access to these files will be granted only to the research team.

### Data analysis

The ActiGraph data will be analysed using ActiLife V.6.13.2 and IBM SPSS Statistics software V.23. The data will be downloaded in 15 s epochs. The wear time validation algorithm of Choi *et al.*<sup>33</sup> will be used: minimum length 10 min, small window length 30 min, spike tolerance 2 min and vector magnitude. The Metabolic Equivalent of Tasks will be calculated using the algorithm of Freedson *et al.*,<sup>34</sup> and the cut-off points and moderate to vigorous PA will be calculated using the algorithm of Evenson *et al.*<sup>35</sup> The minimal wear time should be between 4 and 9 days.<sup>31</sup> If the data have a normal distribution, repeated measures analysis will be performed to assess differences between measurement times. If the data are not normally distributed, the Wilcoxon test will be conducted.

The interview data will be analysed in a content analysis using Atlas.ti V.8 software. Three researchers will independently code a random selection of interviews using the terminology of treatment theory<sup>19</sup> and search for subthemes. They will then discuss their coding tree based on the selected interviews until they reach consensus. This coding tree will be applied to the remaining interviews.

### Ethics and dissemination

The research team will obtain written informed consent from the parents and children aged 12 years (see online supplementary appendices D and E). Participation in the study is voluntary, and care services will not be withdrawn if the potential participants decide not to



partake in the study or withdraw their participation which is possible at any stage of participation. Any protocol amendments will be mentioned in the research article on this intervention. The research team will disseminate the final results to the public through journal publications and presentations for practice providers and scientists. A final study report will also be provided to the funding organisations.

## DISCUSSION

The planned study outlined in this manuscript is the first to evaluate a multidisciplinary family-based intervention targeting motivation for PA of children and parents and indirectly aiming for an increase in the lifestyle PA of children with DCD.

The intervention was developed using the steps for defining a treatment theory<sup>19</sup> which provides a number of advantages. Treatment theory provides concepts that for instance help to distinguish targets from aims. Aims are aspects of functioning that are indirectly influenced by a change in the target. In the current intervention, the aim is to increase the lifestyle PA by targeting the motivation for PA. Moreover, carefully examining the mechanism of action enables one to extract all the relevant dosing parameters. For example, the mechanism of action of 'knowledge' compels us to not merely attend to the content of the information provided, but also to focus on principles on how to transfer knowledge, such as chunking and scaffolding. The use of treatment theory adds to the rigour of intervention development and study design, improves the reporting of interventions and facilitates comparison across interventions with the potential to further advance the research field.

On the other hand, using treatment theory also posed some challenges for the development of the current intervention. First, as noted by Hart *et al.*,<sup>27</sup> it is difficult to define the mechanism of action of psychological interventions. Following their advice, we relied on an existing model of behaviour change, the TTM and a taxonomy of behaviour change strategies. This provided structure but also posed some difficulties for defining the target. Looking at the operationalised essential ingredients of the We12BFit!-Lifestyle PA concepts such as knowledge, skills and cognition might be identified as targets. For example, knowledge is targeted by providing information, skills are targeted by practising problem solving and cognition is targeted by discussing cognitions that may form a barrier for being active. Treatment theory may need further specification on how to formulate targets in psychological interventions. This improves identification of interventions with similar targets and enables comparison of these interventions. Second, applying treatment theory requires an extensive evaluation. Ideally, we should monitor and evaluate the targets and processes described in the mechanism of action to gain insight into the mechanism of action of the intervention. However, as the mechanisms of action are difficult to define and potentially

very comprehensive, we decided to restrict the evaluation to motivation and the aim of PA. The evaluation of the target motivation for PA and the aim of lifestyle PA relies on a mixed-method approach. Targets might also be evaluated using standardised questionnaires, but considering the likely limited concentration span of the children, the limited self-reflective skills of the (younger) children and the nature of the targets, we opted for interviews. This will allow us to combine the evaluation of the effectiveness of the targets and the feasibility of the intervention. Interviews have the potential to provide detailed information, and the respondents are free to comment on any aspect of the intervention instead of only on a predefined set of aspects. Using a mixed-method approach may provide valuable and complementary information on the effects and their qualitative backgrounds.

The content of the intervention is based on the TTM. This model integrates aspects from different theories and allows the intervention to be tailored flexibly to participants in different stages of change. Moreover, the framework allows for working towards a durable change in behaviour. The stages of change have a temporal component, and the maintenance stage of change is said to be reached when the behaviour is overtly changed for at least 6 months. However, given the timeframe of the current study, it will not be possible to establish whether the participants actually reach the maintenance stage of change. The intervention is spread over 12 weeks, a duration that sufficed at short term for instance in the study of Newton *et al.*<sup>26</sup> Moreover, this timeframe allows us to implement all the ingredients, decrease the frequency of the intervention components and limit the risk of participants dropping out due to decreasing motivation.

This intervention is the second part of a more comprehensive intervention that also targets PF through a 10-week group training.<sup>20</sup> Although the two parts can be offered independently, when combined the effects of these two parts might interact and act complementarily. For instance, children may be more inclined to be active because of the PF, motor skills, self-esteem or enjoyment of PA they gained during the PF training. The interviews may provide information on this potential relationship.

To our knowledge, the planned study outlined in this manuscript is the first to describe an intervention directly targeting motivation for PA, eventually aiming for increased lifestyle PA, in children with DCD and their parents. Therefore, it is necessary to gain insight into the feasibility and the preliminary effectiveness of the intervention in order to improve the intervention and to adapt it to the target group. This evaluation may add to our understanding of motivation for PA in children with DCD and may eventually improve the rehabilitation programme of children with DCD.

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